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TO ALL WHOM IT MAY CONCERN:

Be it known that we, Paul Moulton and Brian Moyer, both citizens of United States, whose post office addresses are 504 Highland Terrace, Williamsport, PA 17701 and 17 Vertie Lane, Milton, PA 17847, respectively, have made an invention in

EXPANSION JOINT SYSTEM

of which the following is a

SPECIFICATION

FIELD OF THE INVENTION

[0001] The present invention relates generally to structural expansion joints and more particularly to expansion joints between structural members such as concrete slabs and the like.

BACKGROUND OF THE INVENTION

[0002] Expansion joints are required in most concrete construction. Concrete undergoes physical changes in length, width, height, shape, and volume of its mass in response to changes in the temperature or the mechanical conditions surrounding it. Grooves or expansion joints are placed in a concrete structure to physically subdivide the structure into smaller structural elements. The expansion joints accommodate the compressional forces that are transmitted from abutting structural elements during movement caused by the physical changes in the concrete. Suitably designed expansion joints can preserve the structural integrity and serviceability of the concrete structure. The expansion joints may be covered or filled with flexible sealing material

according to the use of the concrete structure. For example, in common parking structures, parking decks are made of concrete slabs. The concrete slabs are separated by expansion joints, which accommodate expanding or contracting motion of the concrete slabs relative to each other due to weather, traffic loads or seismic activity. Watertight rubber or rubber-like seals are installed in the expansion joints to provide, for example, a continuous driving surface on the parking deck.

[0003] A conventional type of expansion joint seal in use is the so-called bond-in compression seal. This type of seal, which is usually made of thin membranes of rubber-like material, is installed by slipping the seal in a state of compression between the concrete slabs. When the concrete slabs expand, the seal contracts in further compression. Conversely, when the concrete slabs contract, the seal expands in tension. Unfortunately, this often results in seal failure (e.g., by dislodgment) due to the loss of compression. In attempts to minimize such failure, one or more different techniques or methods have been used to bond or attach the rubber seal more securely to the adjoining concrete slabs. In one such method the rubber-like seal is provided with thin lateral wings or flaps. These thin lateral wings or flaps are bonded to cutout or blockout areas in the concrete. The blockout areas may extend along the length of the edges of adjoining concrete slabs. Exposed thin lateral wings or flaps are not designed withstand heavy loads or other wear and tear in use. Therefore, the thin lateral wings or flaps are covered by other protective structures. For example, a resin (e.g., a two-part elastomeric concrete (EC)) may be used to bond the lateral seal wings to the blockout surfaces and to fill in the blockout area above the lateral seal wings. Alternatively, the thin lateral seal wings are secured in position under preformed molded rubber blocks that are bolted to the blockout surfaces using masonry anchor bolts. These conventional methods for holding the expansion joint seals in place are not always

satisfactory. For example, use of resins such as elastomeric concrete can be labor intensive in addition to being environmentally hazardous. Drilling holes in precast concrete to place masonry anchor bolts for securing the preformed blocks may undesirably weaken or otherwise damage the concrete structures. For example, the drilling of holes may undesirably interfere with steel cables that are commonly placed in the concrete, for example, for tensioning parking decks.

[0004] Further in these methods, the nose portions at which the thin lateral seal wings connect to the main seal body (e.g., at the corner of the expansion joint) are still exposed and vulnerable. In some common sealing arrangements, multiple piece structures (e.g., including cover plates and sliding plates) are used to cover the expansion joints to protect the nose portions. However, the installation of multiple piece structures is undesirably complicated.

[0005] Consideration is now being given to ways of improving the characteristics of compression seals installed in concrete expansion joints. In particular, attention is directed to improving the quality and durability of compression seals used in expansion joints, for example, in parking deck structures that are subject to pedestrian and/or vehicular traffic. Attention is also directed to simplifying compression seal installation processes.

SUMMARY OF THE INVENTION

[0006] In accordance with the present invention a one-piece watertight compression seal is provided for sealing expansion joints between separate structural elements of a building. The compression seals may be used, for example, in concrete parking deck structures. The compression seals are designed to withstand repeated automobile wheel impacts or other heavy loads.

[0007] The compression seal has a unitary design in which a compressible sealing portion and a pair of loading-bearing wings are structurally integrated. The compression seal is inherently watertight. The compressible sealing portion, which is designed for placement or insertion in an expansion joint, has a generally rectangular cross-section. The load-bearing wings extend laterally from the compressible sealing portion. The load-bearing wings are designed to have sufficient elasticity and strength so that they can be used with exposed upper surfaces without the need for protective covers or the like. The design of the compression seal advantageously simplifies its installation in an expansion joint. For installation of the compression seal, the compressible portion may be lightly press fit into the expansion joint. The lateral loading-bearing wings are glued or bonded to the surfaces of the structural elements adjoining the expansion joint, to hold the inserted compressible sealing portion in place. By design, the concrete-contacting lower surfaces of the load bearing wings may be provided with longitudinal grooves that encourage gripping or adhesion. The exposed upper surfaces of the load-bearing wings may be corrugated, for example, to provide traction for pedestrian or vehicular traffic.

[0008] The compressible sealing portion has an elastic accordion-like membrane structure. The membrane thickness are selected to provide the accordion-like structure with suitable elasticity to respond to changes in the expansion joint width. In contrast, the thicknesses of the lateral load-bearing wings are selected to provide them with sufficient mass to elastically absorb heavy loads or other wear and tear in use. For this purpose, the vertical thicknesses of the load bearing wings by design may be several times thicker than the thickness of the membranes of the elastic accordion-like structure. Further, the lateral load-bearing wings are connected to the compressible sealing portion at nose portions that are also sufficiently massive and strong to withstand repeated high force impacts in use. The lateral load-bearing wings can be solid but

may include one or more channels or openings running along the length of the compression seal. These openings may be used to house splice joint connectors when splicing shorter lengths of the compression seal together.

[0009] The compression seal can be made by extruding suitable elastic material, for example, ethylene propylene terpolymers including those that are commonly known as EPDM rubber. The tubular design of the compression seal facilitates extrusion of continuous lengths of the compression seal through an extrusion die. Lengths of the compression seal can be cut, notched, and folded as needed for different application geometries.

[0010] Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a cross sectional view of a compression seal installed in an expansion joint of nominal width between two concrete floor slabs, in accordance with the principles of the present invention.

[0012] FIG. 2 is a cross sectional view of the installed compression seal of FIG. 1 under compression when the expansion joint is at about 50% its nominal width, in accordance with the principles of the present invention.

[0013] FIG. 3 is a cross sectional view of the installed compression seal of FIG. 1 under tension when the expansion joint is at about 50% greater than its nominal width, in accordance with the principles of the present invention.

[0014] FIG. 4 is a cross sectional view of a compression seal similar to that of FIG. 1 installed in an expansion joint between a floor slab and a wall structure, in accordance with the principles of the present invention.

[0015] FIG. 5 is a cross-sectional view of a compression seal, which is similar to that of FIG. 4 but which has one of the lateral seal wings removed, installed in an expansion joint between a floor slab and a wall structure, in accordance with the principles of the present invention.

[0016] FIG. 6 is a cross-sectional view of a notched and folded compression seal similar to that of FIG. 1 installed in an expansion joint between stepped concrete slabs, in accordance with the principles of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] The inventive compression seals are designed for use in expansion joints between adjoining structural elements of various geometrical orientations or configurations. The expansion joints may, for example, be between coplanar concrete slabs, between stepped concrete slabs, or between a concrete slab and a wall. An exemplary compression seal 100 includes a dynamic compressible portion 100W supported between lateral load-bearing wings 100a and 100b (FIGS 1-3).

[0018] FIGS. 1-3 show compression seal 100 installed in an expansion joint between a pair of adjoining concrete slabs 110a and 110b, which are substantially coplanar. The expansion joint has a width W between the edge walls of concrete slabs 110a and 110b. The pair of adjoining concrete slabs 110a and 110b may, for example, be precast concrete slabs of the type commonly used in concrete parking deck structures. In such use, expansion joint width W may, for example, have a nominal value of about 2 inches (FIG. 1). Longitudinal cut outs or blockouts 110a' and 110b' are formed in the concrete slabs 110a and 110b along the edges of the expansion joint. Blockouts 110a' and 110b' are designed to receive lateral load-bearing wings 100a and 100b of compression seal 100 when the latter is installed in the expansion joint.

[0019] Compressible portion 100W of seal 100 has a generally rectangular cross sectional shape with sidewalls 12s and at least a top surface. The width of compressible portion 100W (e.g., between sidewalls 12s) may be designed to be the same or slightly wider than the nominal width of the expansion joint, W. The slightly wider width of the compressible portion 100W may be selected to promote an interference fit in the expansion joint. When compression seal 100 is installed in an expansion joint (e.g., FIGS. 1-3) compressible portion 100W is disposed in

the expansion joint space between adjoining concrete blocks 110a and 110b, while lateral load bearing wings 100a and 100b rest on the surfaces of blockouts 110a' and 110b'.

[0020] Compressible portion 100W may have a suitable membrane structure, that is designed to reversibly expand or contract as concrete slabs 110a and 110b move relative to each other in vertical or horizontal directions. Compressible portion 100W may, for example, have an elastic accordion-like membrane structure. The accordion-like structure may be formed by one or more adjacent tubes or channels running along its length. FIGS. 1-3 show an exemplary accordion-like structure, which is made up of hollow tubes or channels 10a, 10b, 10c and 10d that are disposed successively adjacent to each other between sidewalls 12s. Tubes 10a – 10d extend longitudinally along the entire length of compression seal 100. It will be understood that he number of tubes and the inter-tube wall or membrane thickness may be selected to provide the accordion-like structure with suitable elasticity to respond to changes in the expansion joint width. The inter-tube or membrane thickness ("t") may, for example, be less than about a 1/5'' thick depending on the fabrication material used. Further, the elastic accordion-like structure may be designed to allow the top surfaces of compressible portion 100W to remain at about the same height as the latter expands or contracts in response to changes in the width of the expansion joint. FIGS. 2 and 3 respectively show, for example, compressible portion 100W in states of tension and compression in response to an increase of about 50% and a decrease of about 50% in the width of the expansion joint.

[0021] In cross section, compressible portion 100W may have a honeycomb-like appearance as shown, for example, in FIGS. 1-3. Each pair of the successively adjacent hollow tubes 10a - 10d share a common membrane or wall segment that has a generally vertical orientation (e.g., wall

segment 12). The upper wall portions of each of the hollow tubes 10a - 10d may include linear or rounded segments (e.g., linear segment 14) that extend from the common wall segment (e.g., wall segment 12) to a flat or rounded top segment (e.g., wall segment 16). The upper wall portions of the outer most tubes 10a and 10d are structurally connected to adjacent lateral wings 100a and 100b at nose portions 18a and 18b, respectively. This integral connection arrangement may be advantageously designed to provide nose portions 18a and 18b with sufficient mass to withstand adverse or severe conditions in use and to thereby increase the durability of installed compression seal 100. Nose portions 18a and 18b may, for example, be provided with sufficient mass to withstand repeated automobile wheel impacts in parking deck applications. The nose portions 18a and 18b also may be designed to have sufficient flexibility so that lateral wings 100a and 100b are effectively hinged on compressible portion 100W. This flexibility may be advantageous in aligning lateral wings 100a and 100b as needed to conform to the orientation of concrete slab surfaces adjacent to an expansion joint.

[0022] The lower wall portions of each of the hollow tubes 10a - 10d may have a structure that is generally similar to that of the upper wall portions. The lower wall portions of the outer most tubes 10a and 10d may be integrally connected to bottoms of the vertical sidewalls 12s as shown, for example, in FIGS. 1-3.

[0023] Lateral load-bearing wings 100a and 100b extend from the upper portions of compressible portion 100W. The load-bearing wings are structurally designed for use in the field with their top surfaces S exposed. The load-bearing wings can therefore be used without using, for example, of protective covers or fillers (e.g. elastomeric concrete). Each load-bearing wing has a horizontal width W' and a vertical thickness T. The values of W' and T may be

suitably selected to provide the lateral load-bearing wings with sufficient mass so that the lateral load-bearing wings can elastically absorb heavy loads or other wear and tear in use. For this purpose, the vertical thickness of the load-bearing wings may have exemplary values that are several times the thickness of the membranes of the elastic accordion-like structure of compressible portion 100W. The thickness T of the lateral load-bearing wings may, for example, be about or greater than one half of an inch. In the example shown in FIGS. 1-3, the thickness T and the widths W' of the load-bearing wings 100a and 100b have values of about 11/16" and about 3 ¼," respectively.

[0024] For several applications (e.g., parking deck applications), it may be important that the top surface of installed compression seal 100 is substantially coplanar with the surfaces of concrete slabs 100a and 110b. For this purpose, the depths D and widths W" of blockout areas 110a' and 110b' may suitably selected in consideration of the thickness T and the widths W' of the lateral load-bearing wings 100a and 100b. Blockout depths D may be selected to be about the same as lateral load-bearing wing thickness T, so that the top surface of installed compression seal 100 is substantially co-planar with the remaining surfaces of the concrete slabs. Further, the blockout widths W" may, for example, be selected to be slightly larger than lateral load-bearing wing widths W'. The larger widths of the blockout areas ease the placement of smaller width lateral wings 100a and 100b in the block out areas during the installation of compression seal 100. In the example shown in FIGS. 1-3, blockout depth D and width W" have exemplary values of about ¾" and 3 1/2", respectively, to accommodate lateral wings 100a and 100b having the illustrative dimensions cited above (T ~ 11/16" and W' ~ 3 1/4").

[0025] It will be understood that these numerical values given above are exemplary and are cited only for purposes of illustration. In practice, compression seal 100 may be fabricated in various suitable sizes as desired, for example, to fit new or retrofit preexisting expansion joints and blockouts.

[0026] During the fitting process, compression portion 100W is inserted or "zipped" into the expansion joint along the length of the expansion joint. Lateral wings 100a and 100b are received in the blockout areas as compression portion 100W is inserted or zipped into the expansion joint spacing. The process of fitting compression seal 100 in the expansion joint may require only little or minimal force. For example, the weight of a worker walking or stepping over properly aligned compression seal 100 may be sufficient to place compression seal 100 in the expansion joint. Suitable high strength epoxy or other adhesive material may be used to permanently bond the mutually contacting surfaces of compression seal 100 and concrete blocks 110a' and 110b' together. For example, the outer surfaces of sidewalls 12s and the bottom surfaces of lateral wings 100a and 100b may be bonded to contiguous concrete surfaces using a high strength epoxy material 120. In the installation of compression seal 100, a thin layer of epoxy material 120 may be pre-applied or coated along the edge walls of the expansion joint and the top surfaces of block outs 110a and 110b. Then, compression seal 100 may be press fit into the expansion joint so that the epoxied concrete surfaces bind to the undersides of lateral wings 100a and 100b and the outer sides of sidewalls 12s. Caulking material 130 or other suitable fillers may be used to backfill any gap between the edges of block outs 110a' and 110b' and lateral wings 100a and 100b wings to complete the installation of compression seal 100.

[0027] In addition or as an alternate to the use of epoxy adhesives, conventional masonry techniques (e.g., anchor bolts) may be used to secure lateral wings 100a and 100b to the adjoining concrete slabs, if appropriate and so desired.

[0028] Lateral wings 100a and 100b may have solid structure, or alternatively may have a cellular structure. This cellular structure may, for example, be like the tubular structure of compressible portion 100W. FIGS. 1-3 show exemplary lateral wings 100a and 100b made up of one or more successive adjacent hollow tubes or channels (e.g., 20a, 20b, 20c, etc.). Additionally, the lower surfaces of lateral wings 100a and 100b (and the outer surfaces of the sidewalls 12s) may have a pattern of grooves or other gripping features that may be helpful in securing the lateral wings to concrete surfaces. Inset A in FIG. 1 shows an exemplary pattern of longitudinal grooves on the lower surface of lateral wing 100b.

[0029] Compression seal 100 including load-bearing lateral wings 100a and 100b and compressible portions 100W may be fabricated as a one-piece structural unit. High strength elastomers, rubber or rubber-like materials that have suitable physical and chemical characteristics (e.g., elasticity, temperature response, etc.) may be used to fabricate compression seal 100. In a preferred embodiment, compression seal 100 is made from ethylene propylene terpolymer material. Such material may include material that is sometimes referred to in the trade by the acronym "EPDM" rubber. Common extrusion techniques may be used to fabricate compression seal 100 from EPDM rubber. The tubular design of compression seal 100, which has the same cross-section along the length of compression seal 100, can be advantageous in the fabrication of compression seal 100 by extrusion processes. For example, having the same cross

section may advantageously allow substantial lengths of compression seal 100 to be extruded continuously through a suitable extrusion die.

[0030] Continuously extruded lengths of compression seal 100 may be cut to suitable lengths for installation in expansion joints according to need. The shear properties of the rubber-like fabrication material used (e.g., EPDM rubber) facilitate mechanical cutting, trimming or sizing of compression seal 100 in the field. In addition to cutting extruded lengths of compression seal 100 to desired lengths, lengths of compression seal 100 may be notched and folded as needed for use in complex (i.e., non-planar) geometries. Conversely, small length pieces of compression seal 100 may be spliced together to make a larger length piece by using suitable splice joint connectors (e.g., pins or dowels). The cellular spaces (e.g., channels 20a, 20b, 20c, etc.) in the lateral wings 100a and 100b may be advantageously used to receive the splice joint connectors for this purpose.

[0031] FIGS. 4 and 5 show exemplary installations of compression seal 100 in an expansion joint between a horizontal floor slab and a vertical wall structure 400. For the installation shown in FIG. 4, load-bearing wing 100b is cut away and detached from the underlying sidewall 12s, leaving nose portion 18b intact. This cut allows load-bearing wing 100b to be freely lifted or turned around nose portion 18b, for example, to a vertical orientation substantially parallel to underlying sidewall 12s. FIG. 4 shows both underlying sidewall 12s and vertically oriented lateral wing 100b that are bonded to the surface of the vertical wall structure 400. The other lateral wing (100a) is bonded to a blockout in the horizontal floor slab in an horizontal orientation as described above with reference to FIG. 1. The epoxy bonding process and the other steps involved in installing compression seal 100 in the expansion joint between the

horizontal floor slab and vertical wall structure 400 may be generally similar to those in the installation process described above with reference to FIG. 1. For brevity, the description of these steps is not repeated here.

[0032] FIG. 5 shows an alternate arrangement for installation of compression seal 100 in the same expansion joint structures shown in FIG. 4. In the arrangement shown in FIG. 5, the entire lateral load-bearing wing 100b of compression seal 100 is detached or cut away from nose portion 18b. Compression seal 100 is then supported against the surface of wall 400 by bonding only sidewall 12s to the wall surface.

[0033] Compression seal 100 also can be used for more complex expansion joint geometries. FIG. 6 show an exemplary installation of compression seal 100 in an expansion joint between stepped concrete blocks 600a and 600b. Sections A and C of installed compression seal 100 bridge the expansion joint between the horizontal step portions of concrete blocks 600a and 600b. Lateral wings 100a and 100b of sections A and C are supported in horizontal blockouts in a configuration similar to that shown in FIG. 1. Section B of installed compression seal 100 bridges the expansion joint between the vertical riser portions of concrete blocks 600a and 600b. Lateral wings 100a and 100b of section B are bonded to vertical blockouts in the surface of the riser portions. Sections A, B and C may be formed by bending a continuous length of compression seal 100 at suitably sharp angles. Alternatively, sections A, B and C may be partially or completely discontinuous segments of compression seal 100. The first case (partially discontinuous segments) can be obtained, for example, by making notch cuts in lateral wings 100a and 100b so that the lateral wing portions in adjacent sections are disconnected.

[0034] It will be understood that although a number of specific embodiments of the invention above have been illustrated, various modifications thereof will be apparent to those skilled in the art within the spirit of the invention. It will also be understood that terms like "lateral" and "longitudinal," "vertical" and "horizontal," "upper" and "lower," and other terms that connote direction or orientation, are used herein only for convenience, and that no fixed or absolute orientations are intended by the use of these terms.